January 16th 2008, A. Pany

A short note on constraints

Specifications:

schedule: stat16_6_2p1D0ln

clk: ASD 2e-15 @ 15 min, random walk + integrated random walk
zwd: Vienna turbulence (standard)
wn: 4/sqrt(2) ps per station

zwd: 6 min; 15 and 48 mm/h
grd: 6 min; 0.08, 0.5 and 2mm/h
clk: 1h, 1 and 54 mm/h

For schedule stat16_6_2p1D0ln, several estimates were performed with the PPP CLSM simulator using different constraints for zwd, grd and clk in order to assess their impact on the results.

1. Constraints for zwd rates

The default values for zwd constraints for VLBI2010 CLSM simulations are 15 mm/h. This corresponds to a variance rate of 0.7 ps²/s (which is used for the OCCAM KF simulations). However, this is only true, when 1h segments are used for zwd estimation. If zwd is parameterized with shorter time segments, the constraints should be adapted if they should fit the OCCAM KF variance rates:

1) constraints for 1h segments for zwd starting from a variance rate of 0.7 ps²/s:

0.7 ps²/s | · 3600
2520 ps²/1h | √
50.20 ps/1h | ·1e-12 · c · 1e3 (c is speed of light [m/s])
15 mm/h

2) constraints for 6 min segments starting from a variance rate of 0.7 ps²/s:

0.7 ps²/s | · 6 · 60
252 ps²/6m | √
15.87 ps/6m | · 60/6
158.75 ps/1h | ·1e-12 · c · 1e3 (c is speed of light [m/s])
~ 48 mm/h

To assess the impact of using constraints of 15 mm/h for zwd rates instead of 48 mm/h when using 6 min estimation intervals, a comparison was carried out for schedule stat16_6_2p1D0ln. Results can be seen in Figure 1 which shows mean rms of zwd residuals (Figure 1a), mean rms of clk residuals (Figure 1b) and rms of 3D position error (Figure 1c). Mean rms of zwd resiudals and mean rms of clk residuals are slightly smaller when using constraints of 48 mm/h, rms of 3D station position, however, is not significantly influenced.

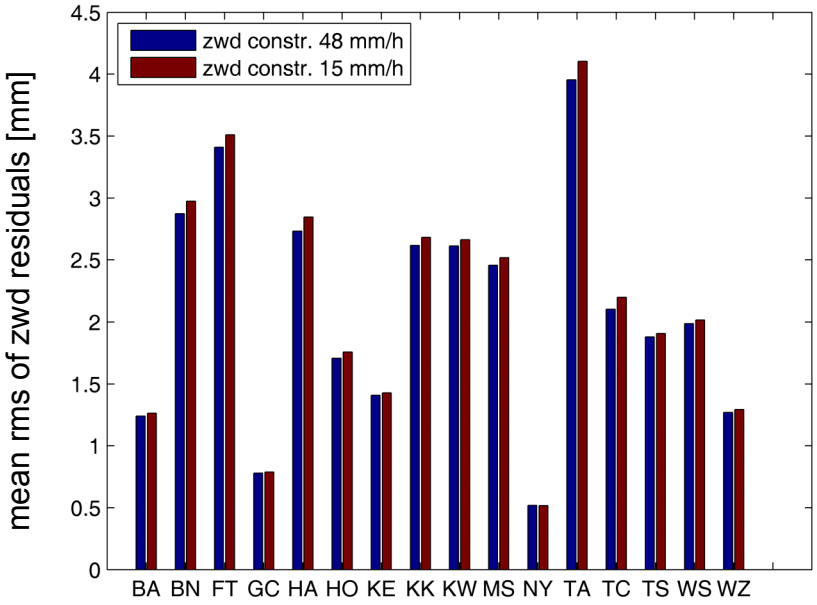

Figure 1a: mean rms of zwd residuals for stat16_6_2p1D0ln using zwd constraints of 48 mm/h (blue) and 15 mm/h (red)

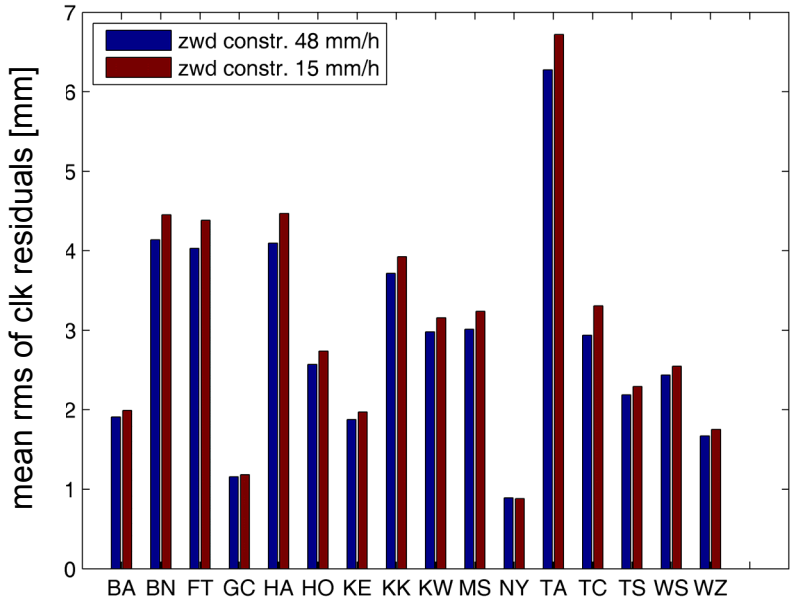

Figure 1b: mean rms of clk residuals for stat16_6_2p1D0ln using zwd constraints of 48 mm/h (blue) and 15 mm/h (red)

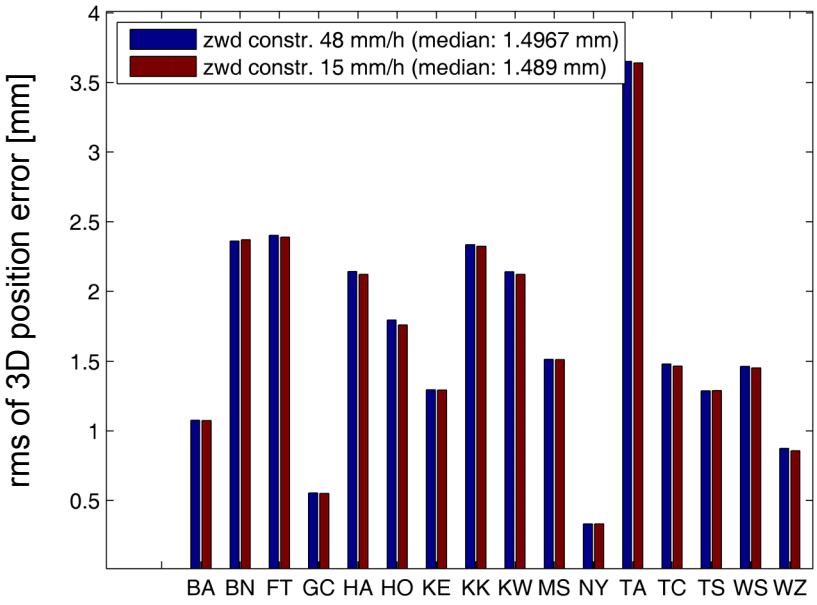

Figure 1c: rms of 3D position error for stat16_6_2p1D0ln using zwd constraints of 48 mm/h (blue) and 15 mm/h (red). The median rms of each estimate is given in the legend.

Table 1: constraints (corresponding to a variance rate of 0.7 ps²/s) for different estimation intervals

estimation interval	constraint
60 min	15 mm/h
12 min	34 mm/h
9 min	39 mm/h
6 min	48 mm/h
5 min	52 mm/h
4 min	58 mm/h
3 min	67 mm/h

2. Constraints for clock rates

The default value for clock constraints is 54 mm/h. That are looser constraints than for zwd. Constraints for a clock can be derived from its ASD as follows:

ASD 2e-15 @ 15 min:

2e-15 [ ] | ²
4e-30 [ ] | · 15 · 60
3.6e-27 s²/s | · 3600
1.3e-23 s²/1h | √
3.6e-12 s/1h | · c · 1e3 (c is speed of light [m/s])
~ 1 mm/h

ASD 1e-14 @ 15 min:

1e-14 [ ] | ²
1e-28 [ ] | · 15 · 60
9e-26 s²/s | · 3600
3.2e-22 s²/1h | √
1.8e-11 s/1h | · c · 1e3 (c is speed of light [m/s])
~ 5 mm/h

To assess the impact of using constraints of 54 mm/h for clk rates instead of 1 mm/h for a clock with an ASD of 2e-15 @ 15 min, a comparison was carried out for schedule stat16_6_2p1D0ln. Results can be seen in Figure 2 which shows mean rms of zwd residuals (Figure 2a), mean rms of clk residuals (Figure 2b) and rms of 3D position error (Figure 2c). As for the comparison of zwd constraints, mean rms of zwd resiudals and mean rms of clk residuals are slightly smaller when using constraints of 1 mm/h, rms of 3D station position is not significantly influenced.

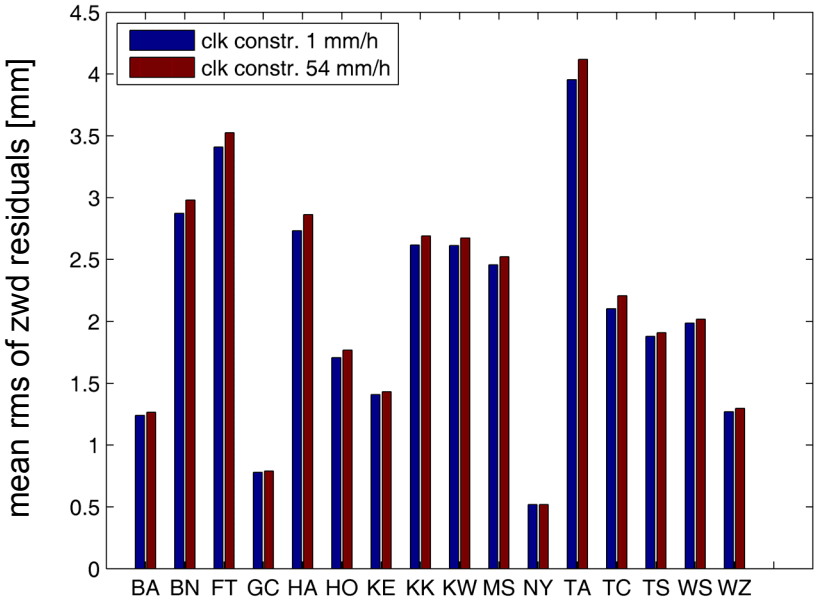

Figure 2a: mean rms of zwd residuals for stat16_6_2p1D0ln using clk constraints of 1 mm/h (blue) and 54 mm/h (red)

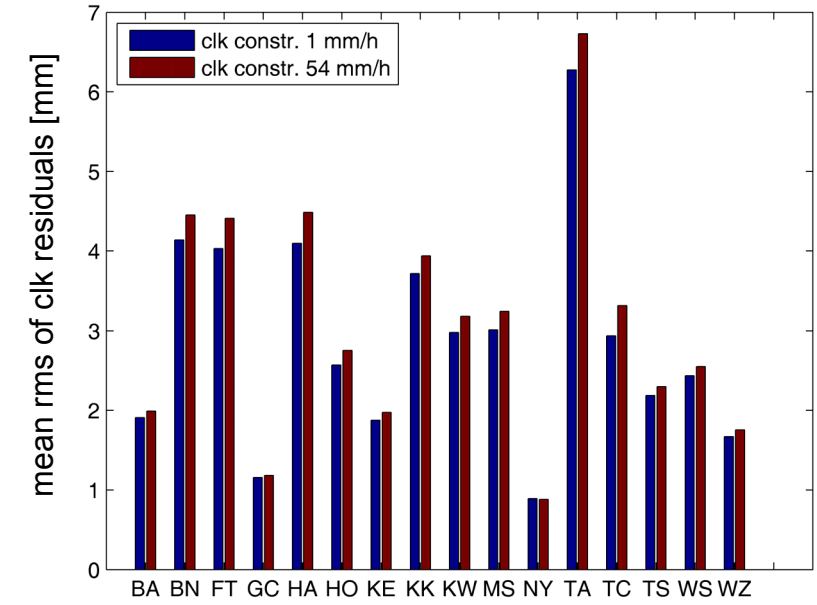

Figure 2b: mean rms of clk residuals for stat16_6_2p1D0ln using clk constraints of 1 mm/h (blue) and 54 mm/h (red)

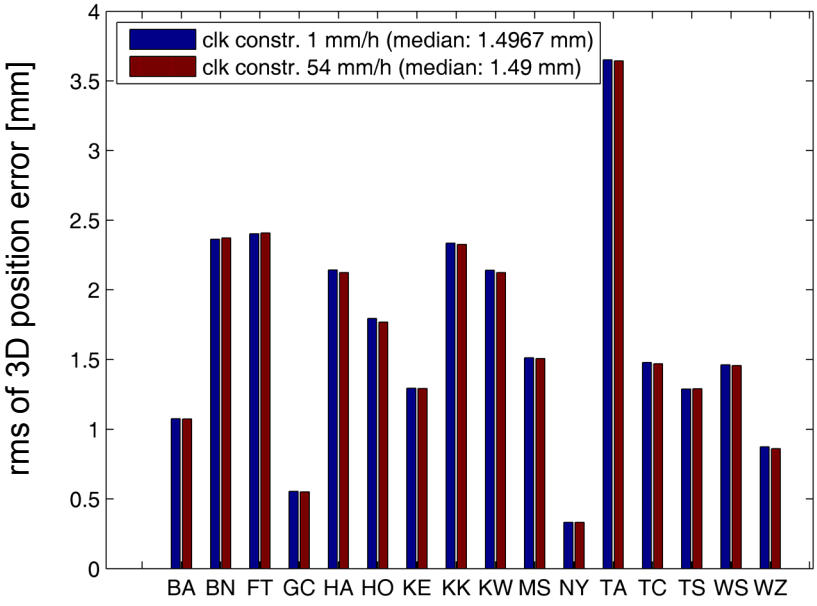

Figure 2c: rms of 3D position error for stat16_6_2p1D0ln using clk constraints of 1 mm/h (blue) and 54 mm/h (red). The median rms of each estimate is given in the legend.

3. constraints for gradient rates

The default value for grd constraints is 2 mm per 24 hours. This corresponds to 0.08 mm/h. For OCCAM KF simulations, variance rates of 0.5 ps²/s are used for gradient estimation. This corresponds to a value of 40 mm/h for CLSM, when using 6 min estimation intervals. For all D0ln schedules, several runs were performed using different constraints for gradients (ranging from 0.08 to 75 mm/h). These investigations revealed that for CLSM with 6 min gradients, 0.5 or 2 mm/h yield best solutions (for all schedules tested). Results for stat16_6_2p1D0ln with grd constraints of 0.08, 0.5 and 2 mm/h can be seen in Figure 3 which shows mean rms of zwd residuals (Figure 3a), mean rms of clk residuals (Figure 3b) and rms of 3D position error (Figure 3c). For mean rms of zwd residuals, the best results are obtained with constraints of 2 mm/h. The values are slightly worse with constraints of 0.5 mm/h and significantly worse with constraints of 0.08 mm. For mean rms of clk residuals, the situation is pretty similar. For rms of 3D station position there is no significant difference between estimates with 2 mm/h and 0.5 mm/h constraints, respectively, but rms values get slightly worse when using 0.08 mm/h constraints.

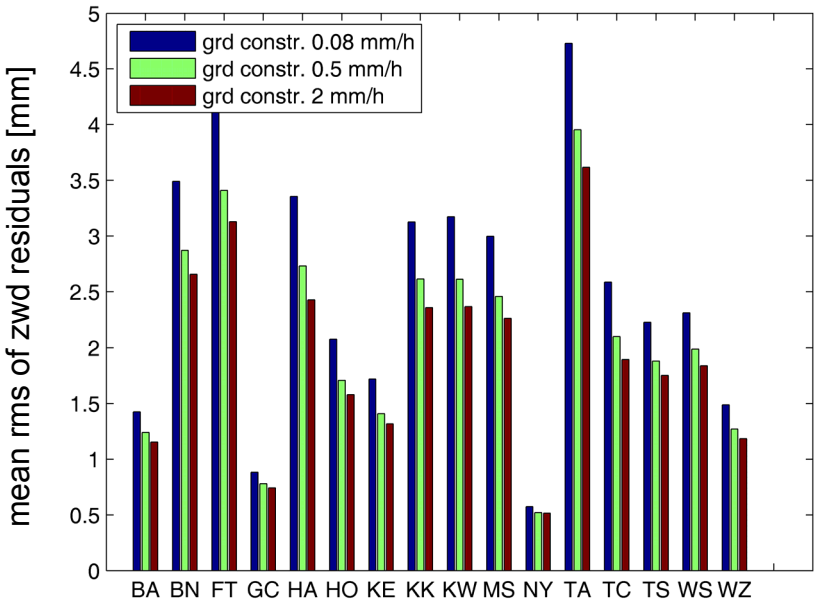

Figure 3a: mean rms of zwd residuals for stat16_6_2p1D0ln using grd constraints of 0.08 mm/h (blue), 0.5 mm/h (green) and 2 mm/h (red)

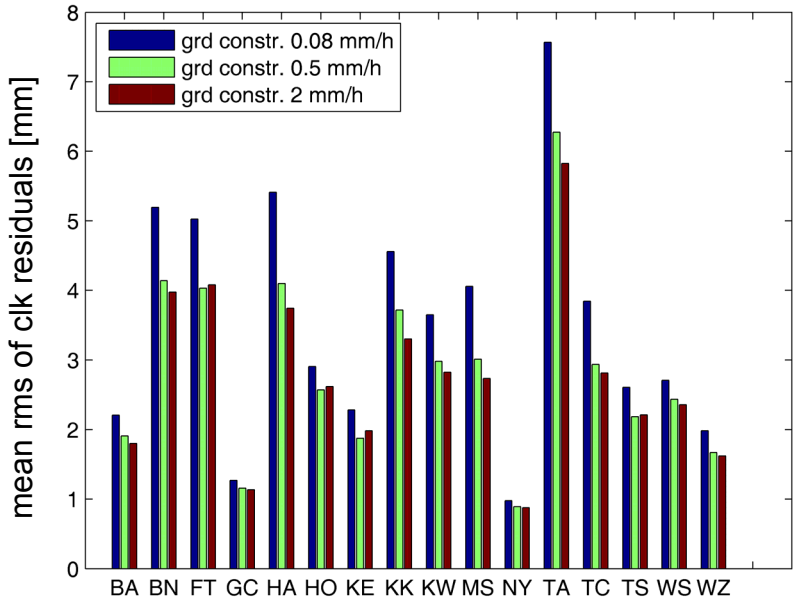

Figure 3b: mean rms of clk residuals for stat16_6_2p1D0ln using grd constraints of 0.08 mm/h (blue), 0.5 mm/h (green) and 2 mm/h (red)

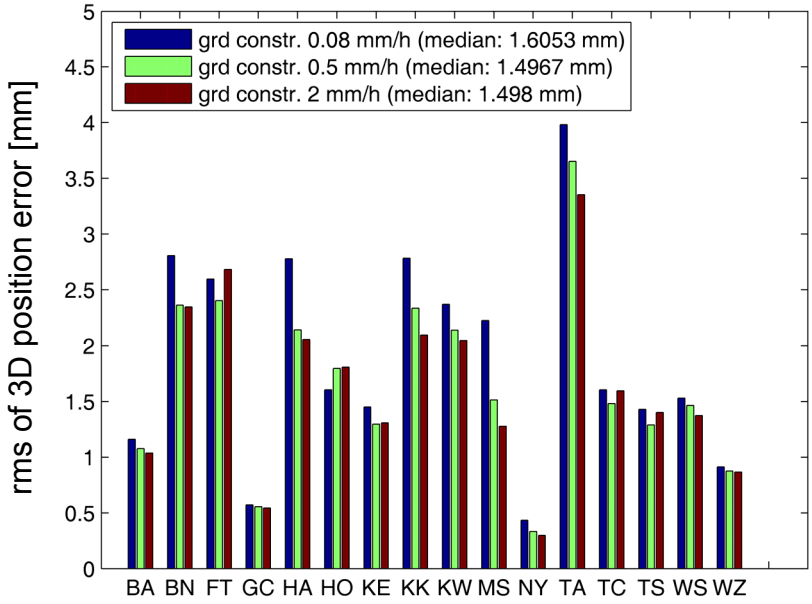

Figure 3c: rms of 3D position error for stat16_6_2p1D0ln using grd constraints of 0.08 mm/h (blue), 0.5 mm/h (green) and 2 mm/h (red). The median rms of each estimate is given in the legend.